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Notes on cultures of *Gymnosporangium* made in 1887 and 1888.

ROLAND THAXTER.

In a paper "On certain cultures of *Gymnosporangium*, with Notes on their *Ræstelia*," published in the proceedings of the American Academy of Arts and Sciences (vol. xxii, p. 259), I gave the results of experiments undertaken in the spring of 1886, at the suggestion of Prof. Farlow, with a view to determine, if possible, the connection existing between the various species of *Gymnosporangium* and *Ræstelia* found in the vicinity of Boston; and since the publication of the paper referred to, similar cultures have been continued yearly, the results of which are given in the present article. In order, however, to make myself intelligible, it may be expedient to summarize my previous results, the more so since my later cultures necessitate some modification of the views then expressed concerning one at least of the *Ræstelia* obtained.

Having in the cultures of 1886 succeeded in obtaining æcidia from five of the seven species of *Gymnosporangium* common in New England, it became necessary to determine with some accuracy to which of the numerous forms of *Ræstelia* these æcidia severally belonged; and to this end a large number of specimens were examined, including numerous examples from European exsiccati, which the kindness of Prof. Farlow placed at my disposal. As a result of this examination, it became evident that the opinions generally accepted in this country concerning the identities existing between the American and European forms were erroneous in several important particulars.

RÆSTELIA *PENICILLATA*, for example, a species incorrectly referred to *R. lacerata*, by certain authors, but very properly retained as distinct by Winter (Pilze, p. 266), was found, after an examination of several authentic European specimens, to be a well-marked form quite different from any known American species. *R. penicillata*, therefore, must be definitely excluded from the list of American forms unless it has been wholly overlooked; a supposition which seems

quite improbable. Turning to the American forms previously included under the name "penicillata" it was found that they included two well-marked species, namely, *R. pyrata* and *R. lacerata*.

RÆSTELIA PYRATA, the *Æcidium pyratum* of Schweinitz, which was obtained from sowings of *G. macropus* upon *Pyrus Malus*, was found to be a peculiarly American form, readily separable from any known European species and not to be confounded with any other American species: from all of which it is readily distinguished by its habit alone, as well as by its microscopic characters. It is distributed in Ellis' N. A. Fungi No. 1086 a, b, and d (*not* c), under the name "penicillata," and also from America in Thuemen's Myc. Un. No. 732 under the name "lacerata." It is very common on *Pyrus malus* and often destructive, but grows most luxuriantly on *P. coronaria*; and may be readily distinguished from the only other *Ræstelia* common upon *Pyrus malus*, by its *revolute* peridial lacerations. I make this statement in detail from the fact that I have subsequently been quoted as considering *R. pyrata* a form of *R. penicillata*, whereas my expressed opinion was exactly the contrary of this statement; and also for the reason that I notice the name "penicillata" still retained by certain American writers when referring to *R. pyrata*, which is a manifest error.

The second form above referred to, which has, in this country, been wrongly considered a form of *R. penicillata*, is beyond question the true

RÆSTELIA LACERATA.—This was obtained from sowings of *G. clavariæforme* on *Cratægus*. In its general habit it bears a superficial resemblance to *R. pyrata*, but the peridial lacerations are only slightly divergent, not *revolute*; while it is also readily separable microscopically. In its most typical form it attacks the fruit and tender shoots of *Cratægus*, and more especially of *Amelanchier*; but it also occurs upon the leaves of both these plants, and has recently been found by Prof. Farlow on the fruit of *Pyrus arbutifolia*, a hitherto unrecorded host. The species is distributed in Ellis' N. A. F. No. 1086 c, in my copy, (*not* a, b or d), under the name "penicillata," and also under the names "*carpopphila* Bagnis" (Myc. Un. 1326) and "lacerata" in various European exsiccati. "*Ræstelia lacerata*," however, as it is commonly understood in this country, is quite another thing. In my previous paper I spoke of the forms referred to *R. lacerata* for the sake of convenience as *lacerata* α , γ and ε : "*lacerata* α " being used

for the true *R. lacerata* as above distinguished; "*lacerata y*" for the form common on *Cratægus*, usually known in this country as the typical *R. lacerata*, and distributed in Ellis' N. A. F. No. 1085 under this name, the specimens labelled "*a*" on *Cratægus coccinea* being the most typical; while "*lacerata z*" was used to designate a small form apparently not distributed, but very common (in New England, at least) upon leaves of *Pyrus Malus*, especially on wild stock. These two forms ("*lacerata y*" and "*z*") I shall have occasion to refer to presently in connection with *G. globosum*. It is, therefore, sufficient to say that I then suggested their identity with

RÆSTELIA CORNUTA.—To this species I was constrained, I think erroneously, to refer the æcidium which followed the infection of *Amelanchier* with what I then considered the American form of *G. conicum*, namely, the common "birds'-nest" *Gymnosporangium* figured in Farlow's "*Gymnosporangia of the U. S.*," plate II, fig. 22, under the name *G. clavipes*, and distributed also as *clavipes* in Ellis' N. A. F. No. 1084 b (*not a*). I say constrained, since the *Ræstelia* was referable to no other described species, and it seemed that the differences between the culture and our supposed forms of *R. cornuta* might have been accidental.

RÆSTELIA BOTRYAPITES, a form not to be confounded with any other American species followed sowings of *G. bisep-tatum* on *Amelanchier*.

RÆSTELIA AURANTIACA which followed sowings of the true *G. clavipes* on *Amelanchier* stems is also too well marked to need further comment. It may be mentioned here, however, that although *Cratægus*, *Amelanchier*, *Pyrus Malus* and *Cydonia* are the only recorded hosts of this species, it has been observed by Prof. Farlow on the fruit of *Pyrus arbutifolia* in Massachusetts, and Mr. Miyabe has kindly sent me a specimen collected by him on the same host at Grand Menan Island.

The experiments with *G. Ellisii* were not satisfactory, while *G. globosum* produced nothing beyond its usual luxuriant and brightly colored spermogonia on *Cratægus*; spermogonia also appearing on *Sorbus* and *Amelanchier*; but in no case producing æcidia, the leaves having withered and fallen off about two months after their infection.

The above contains in general the results of my first cultures. Turning now to those subsequently made the results were as follows. It should be stated at the outset that, like the first set of cultures, those subsequently made were conducted

under conditions as rigid as they could practically be made, a circumstance upon which, I think, too great stress cannot be laid in connection with any experimental work of this nature. In all cases the Gymnosporangia were gathered before they had had an opportunity of becoming mixed; in fact before they were fully mature, and the hosts for infection were in all cases potted plants, started early in the house or greenhouse, and infected in different rooms or buildings, being subsequently kept separate till all danger of accidental mixture was past. It is hardly necessary to point out the superiority of this method over cultures made out of doors, in which the possibility of error cannot be eliminated; but by far the most crucial test in such cases is gained by forcing the fungus as well as its host so as to make the infection a month or more before it would naturally occur out of doors, as was done, for example, in the second culture of *G. globosum* given below. In this way the sources of error are reduced to zero if, as in this case, only one species of Gymnosporangium is used. As in my previous cultures, I have found it more convenient to place the spore masses directly upon the sprinkled leaves, as soon as the sporidia begin to form, and to keep the plants covered with bell glasses or wet paper for one or two days, carefully removing the jelly as soon as these were taken off.

CULTURES OF 1887.

G. MACROPUS.

March 1. Sporidia sown on

2 *Pyrus Malus*,

both host and fungus having been forced in a greenhouse where the subsequent development was watched.

March 10. Spermogonia appeared abundantly on both plants, from which one recovered while the other

May 1, produced æcidia of *Ræstelia pyrata*.

G. CLAVARIÆFORME.

April 24, sporidia sown on

2 *Amelanchier Canadensis*.

April 27, sporidia sown on

1 *Amelanchier Canadensis*.

1 *Crataegus coccinea*.

May 1. Spermogonia appeared on the two first *Amelanchiers*, which were much distorted.

May 5. Spermogonia on the second *Amelanchier*. No result with the *Crataegus*.

May 6. The two first *Amelanchiers* much swollen and distorted, æcidia already beginning to appear.

May 12. *Æcidia* of *Ræstelia lacerata* ("lacerata x") developed luxuriantly on all the *Amelanchiers*. No result with *Cratægus*.

"G. CONICUM."

April 28. Sporidia sown on
2 *Cratægus coccinea*.

May 4. Sporidia sown on
2 *Pyrus Malus*.
2 *Cratægus coccinea*.
1 *Amelanchier Canadensis*.
2 *Sorbus*.

May 8. Leaves of one *P. Malus* much discolored, but no spermogonia developed. Sporidia sown on
1 *Amelanchier Canadensis*.

May 12. Leaves and stems of both *Amelanchiers* much distorted.

May 14. Spermogonia on both *Amelanchiers*. No results with the other plants.

May 24. *Æcidia* began to show on the *Amelanchiers*, which developed into a *Ræstelia* identical with that obtained from the same *Gymnosporangium* in 1886.

G. GLOBOSUM.

During the second week in May (the exact date not recorded) sporidia were sown on large potted plants as follows:

2 *Cydonia vulgaris*.
2 *Pyrus Americana*.
3 *Cratægus coccinea*.
2 (small) *Pyrus Malus*.

Spermogonia appeared abundantly on *all* these hosts in ten days, especially on the *Cratægus*. The plants were watched in the house until June 7, when they were set out in the yard of the house in Boston where the culture was made, and left during the summer. On examination early in September "*lacerata y*" was found developed abundantly on the *Cratægus*, and "*lacerata z*" on two leaves of apples, the leaves having fallen from both the *Cydonia* and *Sorbus*.

CULTURES OF 1888.

G. GLOBOSUM.

March 17. Sporidia sown on
1 *Pyrus Malus*,
3 *Cratægus*,

all having been forced in the greenhouse at the botanic garden in Cambridge.

March 28. Spermogonia appeared abundantly on all the infected plants. These were then watched carefully for three months, at the expiration of which,

June 19. *Æcidia* began to appear on the leaves of the *Crataegus*, while the apple showed swellings beneath the spots of spermogonia. These swellings began slowly to produce *æcidia*, having, as far as could be judged, the characters of "*lacerata z*," but

July 7. The leaves suddenly turned yellow and fell off, while at this date "*lacerata y*" was abundantly developed on the *Crataegus*.

"G. CONICUM."

Two plants of *Amelanchier* were sown with sporidia of the "birds-nest" *Gymnosporangium* for class illustration on May 12, spermogonia appearing in about a week (the exact date not noted), and during the second week in June a *Ræstelia*, similar in all respects to that obtained in the previous years, was well developed upon the stems and leaves.

The cultures of 1887-88, then, agree with the results of the previous year in all respects so far as the *æcidia* obtained from the corresponding *Gymnosporangia* is concerned, and supplement them by the addition of the *æcidial* form of *G. globosum*, the relation of which to any *æcidial* form has heretofore been a most perplexing question. The cultures establishing this relationship which were made in 1888 were, it will be noticed, conducted with the greatest care. The fungus and its host were forced in a greenhouse, and the infection made more than six weeks before it would naturally have occurred out of doors, and the plants were constantly examined during the whole period from infection to the production of *æcidia*. No other species of *Gymnosporangium* was brought into the greenhouse, and when the season for the natural development of the fungus out of doors had arrived, the possibility of infection from without was past. There is, therefore, no shade of doubt connected with the experiment, the result of which is, moreover, supported by the results obtained in the more careless cultures of the previous year. Although in the present instance the culture on apple was not carried as far as could have been desired, I think it may be safely assumed that both "*lacerata y*" and "*lacerata z*" are *æcidia* of *G. globosum*. This conclusion is somewhat of a surprise, since *G. globosum* has been considered a very near ally of the European *G. fuscum*, of which it was originally described as a variety. The *æcidium* of *G. fuscum*, on the other hand, is stated definitely by Mr. Plowright to be *R. cancellata*; a conclusion in harmony with the

views of previous experimenters. But "*lacerata y*" and "*z*" have not the slightest resemblance to *R. cancellata*. On the contrary, as I pointed out in my previous paper, the *Ræstelia* which I called "*lacerata y*" is closely allied to *R. cornuta*, which has been referred by Mr. Plowright, also in concurrence with previous opinion, to *G. conicum*.

Turning for a moment to our birds'-nest *Gymnosporangium*, the question of identities is still further confused by my cultures of this species, made on three successive years with identical results. The *Ræstelia* obtained, as I have mentioned above, was referred to *R. cornuta*, there being no other alternative among described American *Ræstelias*. It seemed not unlikely that the differences between the culture and *R. cornuta* might have been accidental; but the subsequent cultures render this supposition very improbable. In all cases we have the same rapidly-developing *Ræstelia* resembling *R. lacerata* in its mode of growth. In nature the form has probably been confused with *R. lacerata*, with which it must occur simultaneously on *Amelanchier*. It should be noted that upon *Sorbus* (the natural host of *R. cornuta*) the most careful sowings of our "birds'-nest" *Gymnosporangium* have given no result whatever; and also that, although our species is certainly known to occur only on *Juniperus Virginiana*, the European *G. conicum* is found only on *J. communis*. Further careful cultures and observation, together with a more extended examination of European specimens than I have been able to make, will, of course, be necessary to confirm this supposition; but I am decidedly of opinion that our "birds'-nest" species is a distinctly American form as yet unnamed.

Unfortunately, however, we still have to account for what appears to be the typical *R. cornuta* on *Sorbus* collected at Eastport by Prof. Farlow, and subsequently at Grand Menan Island by Mr. Miyabe, and in the White Mountains by Prof. Farlow and myself. In addition also to these, we have unaccounted for a not very common form on *Amelanchier* and one on *Pyrus arbutifolia* found at Kittery, Maine—both of which do not appear to differ essentially from *R. cornuta*. Whether all these forms may not be referable to "*lacerata y*," and consequently to *G. globosum*, I do not feel at present prepared to say; but the only remaining alternative would seem to be that the true *G. conicum* occurs in this country on its proper host (*J. communis*), but has hitherto been overlooked.

Returning for a moment to the cultures of *G. clavariæforme*, it is of interest to note that one of the plants infected in 1887, on which the *Ræstelia* had developed with great luxuriance, was left out of doors over night during a rain, in order to observe the effect thus produced upon its general habit. Before this exposure the peridia had remained unbroken, as is usually the case with cultures carried on indoors; but a single night in the rain was sufficient to induce the typical "penicillate" habit peculiar to the true *R. lacerata*. This circumstance removes any doubts in connection with my determination of this species which may have rested on the failure of my previous culture to assume a lacerate habit. It should be mentioned here that in the Bulletin of the Iowa Agricultural College for 1887, Prof. Halsted describes a culture of *G. clavariæforme* made by him out of doors upon *Amelanchier* with material sent from the east, which resulted in the production of a *Ræstelia* which he referred to *R. botryapites*, thus throwing doubt upon my results both with *G. bisepatum* and *G. clavariæforme*. Prof. Farrow has kindly allowed me to state in this connection that the *Ræstelia* communicated to him by Prof. Halsted as resulting from this culture is certainly *not* *R. botryapites*. That my first result was correct is sufficiently shown by my subsequent cultures, as well as by the conclusions of European experimenters. It is, moreover, quite improbable that a *Gymnosporangium*, also well known in Europe, should produce a *Ræstelia* which occurs only in America.

During the summer of 1887 I had some opportunity of observing the *Ræstelias* occurring in the mountains of North Carolina, concerning which a note may be of interest. At Cullowhee, in the southwest portion of the state, and elsewhere in the same region, cedars (*J. Virginiana*) were not indigenous, but had been introduced in small numbers, and were in most cases loaded with "cedar apples" to a degree seldom if ever met with in the North, and in one case, near the town of Sylva, two large trees seemed to have been literally killed by them, while in several other cases their detrimental effect was apparent. The season of their maturity was passed at the time (June), but the species were readily recognized as *G. macropus* and *G. globosum*, both attaining a remarkable size. I noticed, however, no conspicuous distortions referable to our "birds'-nest" species. Of *Ræstelias* I found three forms. One on *Cratægus Crusgalli*, collected at Sylva, fully developed on June 13, I have been unable

satisfactorily to identify. At Cullowhee two or three small cedars badly infested by *G. macropus* and *G. globosum*, served to infect the region within a distance of a mile or more, and during June and July the *Cratægus* and *Pyrus coronaria*, common in the vicinity, were covered with *spermogonia*. On leaving this locality (July 18) the spots on *Pyrus* were developing a luxuriant growth of *Ræstelia pyrata*, while those on *Cratægus* showed no signs of *æcidia*. This *Cratægus* form was, however, collected and forwarded to me during the following August by my friend Mr. T. B. Cox, and proved to be "*lacerata* *y*"; in other words, the *æcidium* of *G. globosum*, as was to be expected. *Spermogonia* were also seen on *Amelanchier* at the falls of the Tuckasegee river, between Cullowhee and Highlands; but no *æcidia* were procurable. The virulence of *R. pyrata* on certain varieties of cultivated apples in this region was remarkable. I noticed several instances on the road between Sylva and Asheville, where cedars had been planted near small orchards, some of the trees in which were so infested by *R. pyrata* that the bright color was striking at even a considerable distance, while side by side with these were individual trees which showed no sign of the fungus.

In the mountains of East Tennessee, in other respects a mycologist's paradise, no signs of any *Ræstelias* were to be found, although shortly after entering the mountains, I saw abundant *spermogonia* on *Amelanchier* from the car window.

SUMMARY OF CONCLUSIONS.

Ræstelia penicillata is not found in this country so far as is known. The American forms thus named hitherto, include two distinct species, namely, *R. pyrata*, which is the *æcidium* of *Gymnosporangium macropus* and *R. lacerata*, which is the *æcidium* of *G. clavariæforme*.

Ræstelia lacerata, as it is generally known in collections, and as it is distributed in Ellis' N. A. F., No. 1085, is incorrectly named and is the *æcidium* of *G. globosum*, to which should also be referred the smaller form common on *Pyrus malus*.

R. botryapites is the *æcidium* of *G. biseptatum*.

R. aurantiaca is the *æcidium* of *G. clavipes*.

R. cornuta is *not* the *æcidium* of the "birds'-nest" *Gymnosporangium* previously referred to *G. conicum* and distributed as *G. clavipes* in Ellis' N. A. F., No. 1084 (b). The "birds'-nest" form with its *Ræstelia* as obtained by cultures is therefore probably unnamed, unless *G. conicum* is erro-

neously connected with *R. cornuta* by European experimenters. *R. cornuta* as it occurs in this country on *Sorbus*, *Amelanchier* and *P. arbutifolia* either represents variations in the *æcidia* of *G. globosum* or results from the true *G. conicum* which has been hitherto overlooked.

NOTE.—Since the above was in press the writer has found the *Rösetelia* of the ‘bird’s nest’ *Gymnosporangium* growing simultaneously with *R. lacerata* very abundantly on *Amelanchier*, thus confirming the view above expressed. Further details will be given in a subsequent paper, together with notes on cultures made during the present year.

New Haven, Conn.

Flowers and Insects. II.

CHARLES ROBERTSON.¹

Viola pubescens Ait. (fig. 1).—Müller regards the yellow violets as nearest the primitive type. This is yellow with dark nectar-lines. The petaline spur is little more than a gibbosity. The nectar-secreting processes of the lower stamens are very short, being much wider than long. The summit of the peduncle and the flower axis are strongly curved so as to throw the spur well backwards, giving the flower a characteristic appearance,

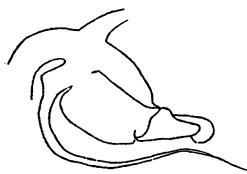


FIGURE 1.

and this serves to limit the insect visits much more than the mere length of the spur. The tips of the anthers and the style are closely approximated to the spurred petal and obstruct the entrance, so that insects unaccustomed to the flower are effectually baffled in their attempts to reach the nectar. The lateral petals are bearded.

The stigma is nearer the anthers than in *V. palmata* and *V. striata*, and self-fertilization in case of insect-absence is more probable.

A proboscis 3 mm. long can secure the nectar, if the bee forces its head in as far as the anthers. Bees receive the pollen mainly on the under side of the head, and work it back into their scopæ, when collecting it. After visiting several flowers, *Osmia* settles upon a fallen leaf and applies the pollen to her ventral scopa, and then returns to the flowers.

After watching the flowers on six days, between April 16 and 30, I obtained only six visitors; but on April 20, 1889, in two hours watching I added twelve new names.

¹On the fertilization of the genus see Müller: Fertilization of Flowers, 117-121 and 634.